**PLANT LISTS**

Given adequate growing medium depth and irrigation, just about any plants, even trees, can be grown on green roofs. The plant list discussions below pertain to extensive green roofs.

While most of the first extensive green roofs in the US were planted with non-native succulent species, mostly Sedum species, the plant palette for green roofs in the US, and in Minnesota, is rapidly expanding to include many herbaceous plants and grasses.

Species included on the plant lists below may not be appropriate for all projects. Suitability can vary with climate, microclimate, project goals, and maintenance budget. Many of these green roof species have not yet been tested in all of Minnesota. While a considerable number of green roofs has been installed in the Twin Cities area, few green roofs have been installed to date in more northern parts of Minnesota, which have a harsher climate that will be more challenging for green roof vegetation.

See Task 5 for guidance on factors that affect green roof plant selection.

**Growing Sedums and other Succulent Plants on Green Roofs**

Sedums and other succulent plants (INSERT Figure 4.1, caption: Sedums on Target Center Arena Green Roof, Image Courtesy of The Kestrel Design Group, Inc.) are often used on green roofs because they are very tolerant of the dry conditions found on most roofs. Durhman et al (2006) found some Sedum species could survive and maintain active photosynthetic metabolism even after 4 months without water! A few of the hardiest ones for Minnesota are listed in Table 1, but these are only a very small portion of the huge palette of Sedums available on the market. Longer lists of succulents available for green roofs, are available, for example, in:

* Getter, K.L.; Rowe, D.B. 2008. Selecting Plants for Extensive Green Roofs in the United States. Michigan State University Extension Bulletin E-3047. Downloaded May 1, 2013 from <http://www.hrt.msu.edu/greenroof/PDF/08%20GetterRoweExtensionBulletin.pdf>
* Snodgrass, E.C. and L.L. Snodgrass. 2006. Green Roof Plants: A Resource and Planting Guide. Timber Press.
* Catalog from Emory Knoll, a green roof plants nursery owned by the authors of the 2006 book about green roof plants by Snodgrass and Snodgrass, catalog can be downloaded from www.greenroofplants.com

Many research studies have studied growth of succulent plants on Midwestern green roofs.

Dvorak and Volder (2010) summarized North American green roof vegetation studies published through March 2010.

Other studies of succulents on Midwestern extensive green roofs that are not included in the Dvorak and Volder (2010) review include:

* Butler, C., & Orians, C. M. (2011). Sedum cools soil and can improve neighboring plant performance during water deficit on a green roof. Ecological Engineering,37(11), 1796–1803.
* Rowe, D. Bradley, Kristin L. Getter, and Angela K. Durhman. "Effect of green roof media depth on Crassulacean plant succession over seven years." *Landscape and Urban Planning* (Elsevier) 104 (2012): 310-319.
* [Whittinghill](http://link.springer.com/search?facet-author=%22Leigh+J.+Whittinghill%22), L.J.; D.B. Rowe, 2011. Salt tolerance of common green roof and green wall plants. [Urban Ecosystems](http://link.springer.com/journal/11252)

14(4):783-794.

**Table 1: Non-Native Succulent species appropriate for Extensive Green Roofs in Minnesota**

Note: Many species of sedums grow well on green roofs in Minnesota. The list below shows some of the most common species. Many other Sedum species can also perform well.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Scientific Name** | **Common Name** | **Plant Height** | **Approximate Bloom Time** | **Flower Color** | **Sun Exposure** | **Winter Interest** |
| Allium schoenoprasum | Chives | 10” | Sp | White | Full Sun to Partial Shade | Dormant |
| Sedum album | Stonecrop | 6” | Su | White | Full Sun | Red |
| Sedum hybridum 'Immergrünchen' | Stonecrop | 6” | Su | Yellow | Full Sun | Orange/Bronze |
| Sedum kamtschaticum var. floriferum'Weihenstephaner Gold' | Russian Stonecrop | 5” | Su | Yellow | Full Sun | Red |
| Sedum kamtschaticum | Russian Stonecrop | 6” | Su | Yellow | Full Sun | Red |
| Sedum reflexum 'Blue Spruce' | Stonecrop | 8" | Su | Yellow | Full Sun | Blue-green |
| Sedum rupestre 'Angelina' | Golden Stonecrop | 5” | Su | Yellow | Full Sun | Coral /Orange-red |
| Sedum sexangulare | Stonecrop | 4” | Su | Yellow | Full Sun to Shade | Red |
| Sedum spurium 'Dragon's Blood' | Two Row Stonecrop | 4” | Su | Red | Sun | Red |

**Growing Native Species on Green roofs**

Many species found in Minnesota’s bedrock bluff prairies have also been found to grow well on Minnesota’s green roofs. Bedrock bluff prairies are prairies with very thin soil layers over bedrock, often found along river bluffs, so plants growing in bedrock bluff prairies are adapted to growing conditions very similar to those found on many green roofs: thin growing medium and high exposure to wind, sun, and drought. (INSERT Figure 4.2: Similarities between bedrock bluff prairies and green roof habitats, image courtesy of The Kestrel Design Group, Inc.) Use of native prairie species on green roofs is controversial, because most prairie species survive droughts by sending roots very deep into the soil to access water from deep down. The shallow growing medium of green roofs does not allow for such deep root growth. However, anecdotal observations in Minnesota, Michigan, Chicago IL and Lincoln NE, suggest that deep rooted native prairie species grow their roots horizontally on green roofs (Kestrel Design Group 2013, Sutton 2011, Grese 2008).

Some studies have found that many native species do not survive on green roofs without irrigation (e.g. Monterusso et al 2005). However, in some projects, even some native species thrive on green roofs without irrigation, or with very minimal irrigation. Since irrigation is needed during the plant establishment period anyway, many green roofs include an automatic irrigation system and can be easily irrigated if needed in times of drought. See task 5 for advantages and disadvantages of irrigating a green roof.

Native species have been planted on at least five extensive green roofs in the Twin Cities area, planted between 2005 and 2009 (See Case Studies for Examples). INSERT Figure 4.3: Native Plants on Target Center Arena Green Roof, Minneapolis, MN, Image Courtesy of The Kestrel Design Group, Inc.; INSERT Figure 4.4: Native Plants on Minneapolis City Hall Green Roof, Minneapolis, MN, Image Courtesy of The Kestrel Design Group, Inc.; INSERT Figure 4.5: Native Plants on Phillips Eco-Enterprise Green Roof, Minneapolis, MN, Image Courtesy of The Kestrel Design Group, Inc. Table 2 lists some of the native species that have performed well on green roofs in Minnesota (Kestrel Design Group observations). Because all of these except for one are irrigated regularly, the ability of most of these species to survive without irrigation on extensive green roofs in Minnesota is not known. Species that have been found to survive with little or no irrigation in Minnesota or elsewhere in the Midwest are noted in table 2.

Many of the species listed in table 2, as well as many additional native species not listed in table 2, are also thriving on other Midwestern extensive green roofs, including, for example, Chicago City Hall (Dvorak and Carroll 2008, Carroll 2013), Chicago Botanic Gardens trial green roofs (Hawke 2013), and several other green roofs in Chicago, Toronto, and Lincoln NE. The Chicago City Hall green roof, installed in 2001 had 200 species as of 2012, most of which are natives. Its plants are grown in varying depths of soil (some extensive and some intensive), and regularly irrigated (Dvorak and Carroll, 2008). The Chicago Botanic Garden has 2 trial green roofs, installed in 2009, one of which is planted with natives. It includes planting depths of 4”, 6” and 8” of growing medium. Aiming to minimize green roof maintenance, they have watered the green roofs only during extreme drought (beyond establishment): once in 2011, and once in 2012 (Sutton et al 2012).

Dvorak and Volder (2010) summarized North American green roof vegetation studies published through March 2010, including those with native species.

Other publications of Midwestern green roofs planted with native species (not listed in Dvorak and Volder’s 2010 literature review) include:

* Getter, K.L.; Rowe, D.B. 2008. Selecting Plants for Extensive Green Roofs in the United States. Michigan State University Extension Extension Bulletin E-3047. Downloaded May 1, 2013 from <http://www.hrt.msu.edu/greenroof/PDF/08%20GetterRoweExtensionBulletin.pdf>
* Sutton, R.K.; J.A. Harrington; L. Skabelund; P. MacDonagh; R. R. Coffman; and G. Koch. 2012. Prairie-Based Green Roofs: Literature, Templates, and Analogs. Journal of Green Building 7(1):143-172.
* Sutton, R.; B. Rowe;G. Acomb; J. Lambrinos; P. MacDonagh; R. Hawke. 2012. New Plant Performance for 21st Century Green Roof Ecosystems. Cities Alive Conference, Chicago IL.
* Torrance, S.; B. Bass, S. MacIvor and T. McGlade in conjunction with Toronto City Planning Division. No publication year given. City of Toronto Guidelines for Biodiverse Green Roofs. Downloaded May 1, 2013 from http://www.toronto.ca/greenroofs/pdf/biodiversegreenroofs\_2013.pdf

Not all the species listed in Table 2 are native in all parts of Minnesota. To find out in which parts of Minnesota these species are native, see, for example:

* Plant species range maps from the Minnesota Department of Natural Resources: <http://files.dnr.state.mn.us/natural_resources/plants/mntaxa_maps.pdf>

For additional information on the species listed in Table 2, including wildlife and other benefits, see

<http://www.wildflower.org/plants/>

**Table 2. Native Species that have been grown successfully on extensive green roofs in Minnesota**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Scientific Name** | **Common Name** | **Plant Height** | **Approximate Bloom Time** | **Flower Color** | **Sun Exposure** | **Found to require irrigation in some projects or studies** | **Found to survive with little or no irrigation in some studies or projects** |
| *Allium cernuum* | Nodding Wild Onion | 1-1.5’ | July – August | Pink | Full Sun to Part Shade |  | X3,4 |
| *Allium stellatum* | Prairie Wild Onion | 1-2’ | July - August | Pink | Full Sun to Part Shade |  |  |
| *Andropogon gerardii* | Big Bluestem | 2-6’ | n/a | n/a | Full Sun to Part Shade |  | X1\*, 2\* |
| *Anemone patens* | Pasque Flower | 0.5’ | April – May | Purple | Full Sun to Part Shade |  |  |
| *Antennaria neglecta* | Field Pussytoes | 0.5’ | April-June | White | Full Sun to Part Shade |  |  |
| *Antennaria plantaginafolia* | Pussy Toes | 1’ | April-June | White | Full Sun to Part Shade |  |  |
| *Aquilegia canadensis* | Columbine | 2-3’ | May – July | Red/Yellow | Full Sun to Full Shade |  |  |
| *Asclepias verticillata* | Whorled Milkweed | 1-1.5’ | June – August | White | Full Sun to Part Shade |  |  |
| *Aster ericoides* | Heath Aster | 1-3’ | July – October | White | Full Sun to Part Shade |  |  |
| *Aster laevis* | Smooth Aster | 1-3’ | August – October | Blue-Violet | Full Sun to Part Shade | X4 |  |
| *Aster lateriflorus* | Calico Aster | 2’ | August – October | White | Full Sun to Full Shade |  |  |
| *Aster macrophyllus* | Large-Leaved Aster | 1-2’ | August – October | Lilac | Full Sun to Full Shade |  |  |
| *Aster novae-angliae* | New England Aster | 3-5’ | August – October | Red-violet | Full Sun to Part Shade |  |  |
| *Aster oolentangiensis* | Skyblue Aster | 3’ | August – October | Blue | Full Sun to Part Shade |  |  |
| *Aster sericeus* | Silky Aster | 1’ | September – October | Purple | Full Sun to Part Shade |  |  |
| *Bouteloua curtipendula* | Side-Oats Grama | 1-3’ | n/a | n/a | Full Sun |  | X1\* |
| *Bouteloua gracilis* | Blue Grama | 0.5-1’ | n/a | n/a | Full Sun |  | X1,5\* |
| *Campanula rotundifolia* | Harebell | 1-1.5’ | June – September | Blue | Full Sun to Part Shade |  |  |
| *Carex pensylvanica* | Pennsylvania Sedge | 0.5’ | n/a | n/a | Full Sun to Full Shade |  |  |
| *Carex vulpinoidea* | Brown Fox Sedge | 1-3’ | n/a | n/a | Full Sun to Part Shade |  |  |
| *Chamaecrista fasciculata* | Partridge Pea | 2-3’ | July-September | Yellow | Full Sun to Part Shade |  |  |
| *Coreopsis palmata* | Bird's Foot Coreopsis | 2’ | June – August | Yellow | Full Sun to Part Shade |  |  |
| *Dalea purpurea* | Purple Prairie Clover | 1-2’ | June – July | Purple | Full Sun | X4 | X1 |
| *Fragaria vesca* | Wild Strawberry | 6” | May-June | White | Full Sun to Full Shade |  |  |
| *Fragaria virginiana* | Wild Strawberry | 6” | May-June | White | Full Sun to Part Shade | X4 | X1\* |
| *Geranium maculatum* | Wild Geranium | 1’ | April-June | Pink | Full Sun to Full Shade |  |  |
| *Geum triflorum* | Prairie Smoke | 6” | April-June | Red | Full Sun to Part Shade |  | X1\* |
| *Heuchera richardsonii* | Alumroot | 1’ | May-June | Greenish White | Full Sun to Full Shade |  |  |
| *Koeleria pyramidata* | Junegrass | 2’ | n/a | n/a | Full Sun to Part Shade | X4 | X1,3,5 |
| *Liatris aspera* | Rough Blazing Star | 1.5-4’ | August – September | Rose, lavender | Full Sun to Part Shade | X4 |  |
| *Liatris cylindracea* | Cylindric Blazing Star | 1’ | July – October | Purple | Full Sun to Part Shade |  |  |
| *Penstemon grandiflorus* | Large-Flowered Beard Tongue | 2’ | May – June | Purple | Full Sun to Part Shade |  |  |
| *Phlox divaricata* | Woodland Phlox | .5-1.5’ | April-June | Blue | Part Shade to Full Shade |  |  |
| *Polemonium reptans* | Jacob's Ladder | 1’ | April-June | Blue | Full Sun to Full Shade |  |  |
| *Ruellia humilis* | *Wild Petunia* | 1’ | June – August | Purple | Full Sun |  |  |
| *Schizachyrium scoparium* | *Little Bluestem* | 3’ | n/a | n/a | Full Sun to Part Shade | X4 |  |
| *Solidago nemoralis* | Gray Goldenrod | .5-2’ | August-October | Yellow | Full Sun |  |  |
| *Solidago ptarmicoides* | Upland White Aster | 1’ | July-August | White | Full Sun |  |  |
| *Sporobolus heterolepis* | Prairie Dropseed | 2-4’ | n/a | n/a | Full Sun to Part Shade | X4 | X1 |
| *Thalictrum dioicum* | Early Meadow-Rue | 1-2’ | May | Greenish-Yellow | Full Shade to Part Shade |  |  |
| *Tradescantia bracteata* | Bracted Spiderwort | 1’ | May – July | Purple | Full Sun |  |  |
| *Tradescantia occidentalis* | Western Spiderwort | 2’ | May – July | Blue | Full Sun |  |  |
| *Tradescantia ohiensis* | Ohio Spiderwort | 3’ | May – July | Blue | Full Sun to Part Shade | X3,4 |  |
| *Viola pedatifida* | Bearded Birdfoot Violet | 0.5’ | April – June | Purple | Full Sun to Part Shade |  |  |

\* goes dormant or turns brown with little or no irrigation in drought but rebounds when water is available again

1Based on trial green roofs at Chicago Botanical Garden, Richard Hawke, Personal Communication

2 Based on Kevin Carroll, personal communication, 2013.

3 Based on research at Michigan State University, Rowe in Sutton et al 2012b

4 Based on research at Michigan State University, Monterusso et al 2005. In this study, plants were irrigated the first growing season, and irrigation was then abruptly stopped July 10 of the second growing season, during an unusually warm and dry summer; plants were not irrigated at all during the third growing season.

5 Based on observations at Phillips Eco-Enterprise green roof, The Kestrel Design Group personal communication, 2013.

**Growing Non-Native Perennials and Grasses on Green Roofs**

While some drought tolerant non-native perennials would be expected to thrive on extensive green roofs, to our knowledge very little if any green roofs in Minnesota have attempted to grow perennials on extensive green roofs.

**Growing Edible Plants on Green Roofs**

Many vegetables and herbs also thrive on green roofs, many in growing medium as little as four inches deep, such as, for example, herbs, tomatoes, peppers, and lettuce. Because they are annuals, vegetables require considerably more maintenance than other extensive green roof plants. If they are fertilized, they will likely increase nutrient content of runoff from the roof, so they may not be ideal for stormwater projects where leaching of nutrients is a concern. If all runoff from the green roof is harvested and re-used on the roof, fertilization will not affect down stream water bodies.

Aside from growing food in a built in place green roof, food can also be grown in containers or hydroponically on a green roof, or on a green or living wall.

The St Paul, MN, firestation is a premier local example of growing food on a green roof. Many other examples of growing food on residential and commercial green roofs can also be found in the US and Canada, including, for example:

* Brooklyn Grange, a one acre (43,000 square foot) farm in Queens rooftop farming and intensive green roofing business located on two roofs in New York City, which grows over 40,000 lbs of organically-cultivated produce per year (http://www.brooklyngrangefarm.com/aboutthegrange/
* Eagle Street Rooftop Farm 6,000 square foot green roof organic vegetable farm located atop a warehouse rooftop owned by [Broadway Stages](http://broadway-stages.com) in Greenpoint, Brooklyn (http://rooftopfarms.org/)

Several on-line references provide more detail about rooftop agriculture, including, for example, *Guide to Setting Up Your Own Edible Rooftop Garden*, Published by Alternatives and the Rooftop Garden Project, 2008, downloaded 04/15/2013 from <http://archives.rooftopgardens.ca/files/howto_EN_FINAL_lowres.pdf>

Other recent publications on rooftop agriculture include:

* Mandel, L., 2013, EAT UP; The Inside Scoop on Rooftop Agriculture. New Society Publishers: Gabriola Island, BC, Canada.
* Whittinghill, L.J. and D.B. Rowe.  2012.  The role of green roof technology in urban agriculture.  Renewable Agriculture and Food Systems 27(4):314-322.
* Whittinghill, L.J., D.B. Rowe, and B.M. Cregg.  2013.  Evaluation of vegetable production on extensive green roofs.  Agroecology and Sustainable Food Systems 37(4):465-484.

Additionally, Green Roofs for Healthy Cities offers a half day course on Rooftop Agriculture: Introduction to Rooftop Urban Agriculture (http://www.greenroofs.org/index.php/education/halfdaycourses).

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* [Whittinghill](http://link.springer.com/search?facet-author=%22Leigh+J.+Whittinghill%22), L.J.; D.B. Rowe, 2011. Salt tolerance of common green roof and green wall plants. [Urban Ecosystems](http://link.springer.com/journal/11252) 14(4):783-794.